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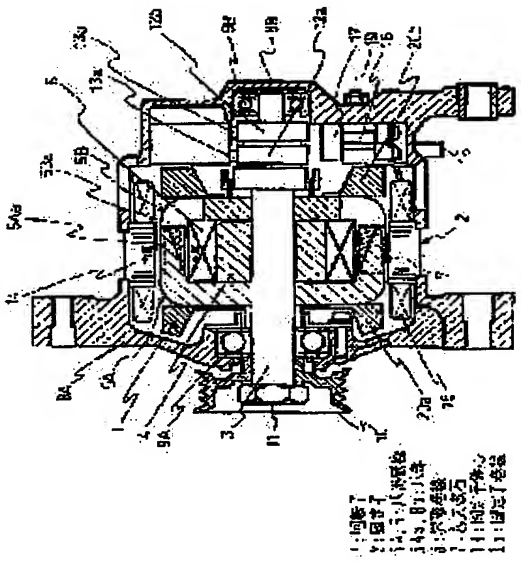
(54) ALTERNATOR FOR VEHICLE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an alternator for a vehicle which can improve an output by effectively utilizing a magnetic flux of a permanent magnet disposed between claw magnetic poles.
SOLUTION: In the alternator for a vehicle, in which the permanent magnet 7 is disposed between a plurality of claw potions 5Aa, 5Ba provided to a pair of claw type magnetic poles 5A, 5B arranged opposed to each other, and a rotor 1 wound with a field coil 6 in the internal side of the diameter direction relative to the plurality of claw portions 5Aa, 5Ba and a stator 2 wound with a stator coil 15 at its stator iron core 14 are also provided. Moreover, the claw portions 5Aa, 5Ba of the rotor 1 are formed in a shape so as to be in contact with the entire surface of the magnetic poles of the permanent magnet 7.



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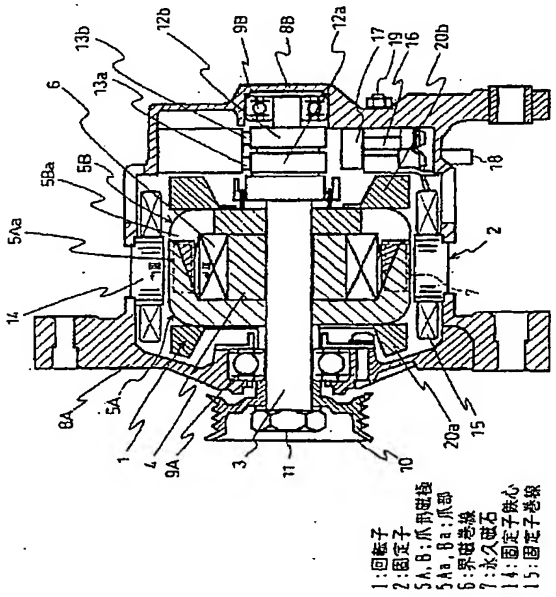
(54)【発明の名称】　車両用交流発電機

(57)【要約】
【課題】爪磁極間に配置した永久磁石の磁束を有効に活用することにより、出力を向上することができる車両用交流発電機を提供する。
【解決手段】対向配置された一対の爪形磁極５Ａ，５Ｂにそれぞれ複数設けた爪部５Ａａ，５Ｂａ間に永久磁石７を配置し、複数の爪部５Ａａ，５Ｂａに対しその径方向内側に界磁巻線６を巻回した回転子１と、固定子鉄心１４に固定子巻線１５を巻回した固定子２とを備えた車両用交流発電機に、回転子１の爪部５Ａａ，５Ｂａを、永久磁石７の磁極面全面と接触するような形状とする。



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【特許請求の範囲】

【請求項１】対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、

前記回転子の爪部を、前記永久磁石の磁極面全面と接触するような形状としたことを特徴とする車両用交流発電機。

【請求項２】請求項１記載の車両用交流発電機において、前記爪部は、前記永久磁石の前記磁極面全面と接触する補助磁極部を有することを特徴とする車両用交流発電機。

【請求項３】請求項２記載の車両用交流発電機において、前記補助磁極部は、その前記回転子の径方向内側の幅寸法に比べ、前記回転子の径方向外側の幅寸法の方が相対的に厚く形成されていることを特徴とする車両用交流発電機。

【請求項４】請求項１記載の車両用交流発電機において、前記爪部を、その前記回転子の径方向内側の面が、前記回転子の径方向外側の面に対して略平行となるように形成したことを特徴とする車両用交流発電機。

【請求項５】請求項４記載の車両用交流発電機において、前記複数の爪部を略リング状の連結部材で連結したことを特徴とする車両用交流発電機。

【請求項６】請求項１～５のいずれか１項記載の車両用交流発電機において、前記爪部は、前記永久磁石を保持する磁石保持部を有することを特徴とする車両用交流発電機。

【請求項７】対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、

前記爪部と前記永久磁石との間に、前記永久磁石の磁極面全面と接触する補助磁極板を介設したことを特徴とする車両用交流発電機。

【請求項８】請求項７記載の車両用交流発電機において、前記補助磁極板は、前記永久磁石を保持する磁石保持部を有することを特徴とする車両用交流発電機。

【請求項９】請求項１～８のいずれか１項記載の車両用交流発電機において、前記永久磁石の少なくとも前記回転子の径方向外側に保護部材を配設したことを特徴とする車両用交流発電機。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は車両用交流発電機に係り、特に補助励磁用の永久磁石を備えた車両用交流発電機に関する。

【０００２】

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【従来の技術】通常、車両用交流発電機は回転子と固定子から構成され、一般的に、回転子は、対向配置された一対の爪形磁極と、これら爪形磁極にそれぞれ複数設けられた爪部に対してその径方向内側に巻回され、電流を流すことにより先の一対の爪形磁極をＮ極及びＳ極に磁化させる界磁巻線とからなる。また、固定子は、固定子鉄心に出力用の固定子巻線を巻回したもので、先の回転子はこの固定子に対して相対的に回転するようになっている。

【０００３】このような構造により、Ｎ極に磁化した爪形磁極から出た磁束は、固定子鉄心を介してＳ極に磁化した爪形磁極に戻る磁気回路を形成し、この磁気回路の磁束が固定子の固定子巻線に差交し、また回転子が回転することにより、固定子巻線に交流の誘起電圧が発生するようになっている。

【０００４】ここで、このような構造の車両用交流発電機においては、例えば爪形磁極間に補助励磁用の永久磁石を介在させることにより、爪形磁極間での漏洩磁束を減じるとともに、界磁巻線の磁束を増磁させ、発電機の出力を向上させることが行われている。このように、爪形磁極間に補助励磁用の永久磁石を配置した車両用交流発電機としては、例えば、特開平１１－３１８０６４号公報に記載された車両用交流発電機等がある。

【０００５】

【発明が解決しようとする課題】しかしながら、上記従来技術には、以下の課題が存在する。通常、爪形磁極の爪部は、その先端部を軽量化するため、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形状に形成されている。これは、爪形磁極の爪部が片持ち支持構造であるため、回転子が高速回転する場合等に、爪部の先端部が遠心力により回転子の径方向外側へ起き上がることを防止するように配慮されているためである。そのため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の回転子の周方向の側面（すなわち磁極面）に爪部と接触しない部分が生じ、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されていない場合がある。

【０００６】上記従来技術においても、爪部の回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形状となっている。また、この従来技術においては、回転子の径方向の厚みが比較的薄い永久磁石を用いているが、爪部の永久磁石との接触面形状に対しては特に考慮されておらず、やはり爪部の先端部付近において、永久磁石の磁極面に爪部と接触しない部分が存在し、永久磁石の磁束が有効に活用されていない可能性がある。

【０００７】本発明の目的は、爪磁極間に配置した永久磁石の磁束を有効に活用することにより、出力を向上することができる車両用交流発電機を提供することにある。

【０００８】
【課題を解決するための手段】（１）上記目的を達成するために、本発明は、対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記回転子の爪部を、前記永久磁石の磁極面全面と接触するような形状とする。
【０００９】前述のように、通常、爪形磁極の爪部は、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形状に形成されているため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の回転子の周方向の側面（磁極面）に爪部と接触しない部分が生じる。すなわち、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されない場合がある。
【００１０】そこで本発明においては、爪形磁極の爪部を永久磁石の磁極面全面と接触するように形成する。これにより、永久磁石から出た磁束は、ほぼ全てが爪部に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。
【００１１】（２）上記（１）において、好ましくは、前記爪部は、前記永久磁石の前記磁極面全面と接触する補助磁極部を有する。
【００１２】（３）上記（２）において、好ましくは、前記補助磁極部は、その前記回転子の径方向内側の幅寸法に比べ、前記回転子の径方向外側の幅寸法の方が相対的に厚く形成されている。
【００１３】（４）上記（１）において、また好ましくは、前記爪部を、その前記回転子の径方向内側の面が、前記回転子の径方向外側の面に対して略平行となるように形成する。
【００１４】（５）上記（４）において、好ましくは、前記複数の爪部を略リング状の連結部材で連結する。
【００１５】（６）上記（１）～（５）のいずれか１つにおいて、さらに好ましくは、前記爪部は、前記永久磁石を保持する磁石保持部を有する。
【００１６】（７）上記目的を達成するために、また本発明は、対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記爪部と前記永久磁石との間に、前記永久磁石の磁極面全面と接触する補助磁極板を介設する。
【００１７】本発明においては、爪部と永久磁石との間に永久磁石の回転子の周方向側面（磁極面）全面と接触する補助磁極板を介在させる。これにより、永久磁石から出た磁束は、ほぼ全てが補助磁極板を介して爪形磁極に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。
【００１８】（８）上記（７）において、好ましくは、前記補助磁極板は、前記永久磁石を保持する磁石保持部を有する。
【００１９】（９）上記（１）～（８）のいずれか１つにおいて、また好ましくは、前記永久磁石の少なくとも前記回転子の径方向外側に保護部材を配設する。
【００２０】
【発明の実施の形態】以下、本発明の実施の形態を図面を用いて説明する。図１は、本発明の車両用交流発電機の第１の実施の形態の全体構造を表す断面図である。この図１において、本実施の形態の車両用交流発電機は、主な構成要素として回転子１と固定子２とを備えている。この回転子１は、シャフト（回転軸）３と、このシャフト３をその回転中心に挿通したヨーク４と、同様にシャフト３をその回転中心に挿通し、ヨーク４を介して回転子１の軸方向（図１中左右方向）に所定間隔を隔てて対向配置され、それぞれ磁性体により構成された一対の爪形磁極５Ａ，５Ｂと、ヨーク４に巻回した界磁巻線６とから構成されている。
【００２１】なお、先の爪形磁極５Ａ，５Ｂには、それぞれ爪部５Ａａ，５Ｂａが複数設けられている。これら爪部５Ａａ，５Ｂａは、図１に示すように、回転子１の周方向から見て、回転子１の軸方向（図１中左右方向）に交互に重なり合うように配置されており、回転子１の周方向に隣接する各爪部５Ａａ，５Ｂａ間には、それぞれ補助励磁用の永久磁石７が介在して配置されている。また、上記したヨーク４に巻回された界磁巻線６は、これら爪部５Ａａ，５Ｂａに対し、所定の間隙空間を隔てて回転子１の径方向内側に位置している。
【００２２】上記したシャフト３は、エンドブラケット８Ａ，８Ｂからなる発電機本体に対し、その一方側（図１中左側）端部近傍をベアリング９Ａに、他方側（図１中左側）端部をベアリング９Ｂにより回転自在に支持されている。また、このシャフト３の一方側（図１中左側）端部には、プーリ１０がボルト１１により締結されており、他方側（図１中左側）端部近傍には、スリップリング１２ａ，１２ｂが設けられている。なお、プーリ１０は、例えば、図示しないエンジンのクランクプーリ等とベルト等により連結されている。
【００２３】また、先のエンドブラケット８Ｂ内部には、スリップリング１２ａ，１２ｂの外周に摺接するようにブラシ１３ａ，１３ｂが設けられており、これらブラシ１３ａ，１３ｂ及びスリップリング１２ａ，１２ｂを介し、回転する回転子１の界磁巻線６に電力を供給す

るようになっている。このように界磁巻線６に通電することにより、前述の回転子１の爪形磁極５ＡがＳ極に、爪形磁極５ＢがＮ極に磁化されるようになっている。

【００２４】前述した固定子２は、回転子１の径方向外側（図１で見ると上下側）に、爪部５Ａａ，５Ｂａと僅かな空隙を隔てて先のエンドブラケット８Ａ，８Ｂに挟持されて設けられた固定子鉄心１４と、この固定子鉄心１４に３相に巻回された出力用の固定子巻線１５とから構成され、回転子１はこの固定子２に対して相対的に回転するようになっている。すなわち、この固定子２においては、上記のようにＮ極に磁化した爪形磁極５Ｂから出た磁束が固定子鉄心１４を介してＳ極に磁化した爪形磁極５Ａに戻る磁気回路を形成し、この磁気回路の磁束が固定子巻線１５に差交し、また回転子１が回転することにより、固定子巻線１５に交流の誘起電圧が発生するようになっている。

【００２５】また、先のエンドブラケット８Ｂ内部には、整流回路１６及び電圧調整器１７が設けられている。整流回路１６は、バッテリー（図示せず）のプラス電極に接続されるバッテリー端子１８と、バッテリー（図示せず）のマイナス電極に接続されるアース端子１９とを有し、上記のように固定子巻線１５で発生した交流の誘起電圧を整流し直流電圧に変換するようになっている。また、電圧調整器１７は、上記図示しないバッテリーを充電するために、整流回路１６により整流された直流電圧が、例えば１４．５Ｖ程度の一定電圧に保たれるように、負荷電流と回転子１の回転数に応じて界磁巻線６に通電する電流を制御するようになっている。

【００２６】なお、回転子１の軸方向（図１中左右方向）両側には、固定子２及び整流回路１６を空冷する冷却ファン２０ａ，２０ｂがそれぞれ設けられており、その風量は、回転子１の回転数に比例して得られるようになっている。

【００２７】上記構成の本実施の形態において、本発明の最も大きな特徴は、前述した回転子１の爪部５Ａａ，５Ｂａを、永久磁石７の回転子１の周方向側面（すなわち磁極面）全面と接触するような形状としたことである。

【００２８】ここで、図２は爪部５Ａａの詳細構造を表す側面図、図３は爪部５Ａａ，５Ｂａと永久磁石７との配置関係を表す図で、先の図１中III－III断面による断面図である。なお、図３には、繁雑防止のため、爪部５Ａａ，５Ｂａを１極分づつ図示した。すなわち、これら図２及び図３に示すように、爪部５Ａａ，５Ｂａは、その回転子１の周方向両側部分を除き、図２中破線で示したように従来と同様、回転子１の軸方向（図２中左右方向）の断面が先端方向（図２中右方向）に向かって細くなるような三角形状に形成されている。永久磁石７は、その回転子１の周方向（図３中左右方向）側面（磁極面）がほぼ長方形状に形成されており、前述のように爪

部５Ａａ，５Ｂａの回転子１の軸方向（図２中左右方向）に重なり合った部分の間に介設されている。

【００２９】このとき、爪部５Ａａ，５Ｂａの回転子１の周方向（図３中左右方向）両側の側面（すなわち、爪部５Ａａ，５Ｂａの重なり合った部分）には、永久磁石７の両磁極面全面と接触する補助磁極部２１が設けられている。この補助磁極部２１は、本実施の形態においては、永久磁石７の磁極面とほぼ同型状をなすように形成され、永久磁石７に対して密着するようになっている。なお、爪部５Ａａ，５Ｂａにおける回転子１の周方向（図３中左右方向）両端の回転子１の径方向外側（図３中上側）には、突起状のつば部２２が設けられており、回転子１の回転により永久磁石７が飛び出すことを防止するように配慮されている。

【００３０】次に上記構成の本実施の形態の車両用交流発電機の動作について説明する。上記のように、まず、例えば図示しないエンジン等から動力を受けて回転する回転子１の界磁巻線６に、ブラシ１３ａ，１３ｂ及びスリップリング１２ａ，１２ｂを介して電力が供給され、回転子１の爪形磁極５ＡがＳ極に、爪形磁極５ＢがＮ極に磁化される。Ｎ極に磁化した爪形磁極５Ｂから出た磁束は、固定子２において、固定子鉄心１４を介してＳ極に磁化した爪形磁極５Ａに戻る磁気回路を形成する。このとき、界磁巻線６が作る磁気回路は、補助励磁用の永久磁石７の磁束が加わることにより増磁される。そして、この磁気回路の磁束は、固定子巻線１５に差交し、回転子１の回転により固定子鉄心１５に３相に巻回された固定子巻線１５に交流の誘起電圧が発生する。

【００３１】そして最終的に、発生した電圧は整流回路１６により整流され直流電圧に変換されて図示しないバッテリーに充電される。またこのとき、この整流回路１６により整流された直流電圧を図示しないバッテリーに充電するために、発生電圧が例えば１４．５Ｖ程度の一定電圧に保たれるよう、負荷電流と回転子１の回転数に応じて界磁巻線６に通電する電流を電圧調整器１７により制御する。

【００３２】ここで、本実施の形態の作用を以下に順次説明する。

（１）高出力化

通常、爪形磁極の爪部は、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形状に形成されているため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の磁極面に爪部と接触しない部分が生じる。すなわち、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されない場合がある。

【００３３】そこで本実施の形態においては、爪形磁極５Ａ，５Ｂの爪部５Ａａ，５Ｂａを永久磁石７の磁極面全面と接触するように形成したので、永久磁石７から出た磁束のほぼ全てを爪部５Ａａ，５Ｂａに流入させるこ

とができる。これにより、永久磁石７の作る磁気回路に作用する磁気抵抗を小さくすることができ、永久磁石７の磁束を有効に活用することができるので、車両用交流発電機の出力を向上することができる。

【００３４】（２）低価格化

また、本実施の形態においては、上記（１）の作用により、永久磁石７を小型化しても、その磁束が有効に活用され効率的に出力を向上させることができるので、車両用交流発電機の製造コストを低減させることもできる。

【００３５】（３）高温減磁の抑制

例えば、補助励磁用の永久磁石としてネオジム磁石を用いた場合、温度が上昇すると非可逆減磁ポイントの屈曲点が変化するため、パーミアンス係数が低いと磁束密度が低くなる場合（高温減磁）がある。この場合、従来のように、永久磁石の磁極面の全面に接触しない爪形磁極を用いると、その永久磁石の磁極面の爪形磁極に接触しない部分の磁束に対する磁気抵抗が大きくなるので、部分的にパーミアンス係数が下がる場合があった。

【００３６】ここで、その磁極が磁性体に接していない永久磁石の動作点と、両磁極が磁性体に接している磁石の動作点とでは、通常、両磁極が磁性体に接している磁石の方が、そのパーミアンス係数が高く、動作点の磁束密度は高くなる。本実施の形態においては、永久磁石７の両磁極が全面爪形磁極５Ａ，５Ｂ（厳密には補助磁極部２１'）に接触しているので、高温減磁に対しての影響を小さくすることができ、永久磁石７の減磁に対する余裕度を上げることができる。

【００３７】（４）永久磁石の着磁容易化

車両用交流発電機の製造方法としては、金属屑等の鉄粉の付着防止等への配慮から、補助励磁用の永久磁石を未着磁の状態で爪形磁極間に配置し、回転子の回転バランスを調整した後、回転子の製造工程の最終段階で例えば外部の着磁ヨーク（図示せず）等により永久磁石を着磁することが一般的に行われている。本実施の形態においては、このような場合、永久磁石７の回転子１の周方向側面の全面に磁性体で構成された爪形磁極５Ａ，５Ｂ（厳密には爪部５Ａａ，５Ｂａ）が接触しているため、未着磁の永久磁石７に対し十分な磁束を通すことができ、永久磁石７の着磁作業を容易にすることができる。

【００３８】なお、以上説明してきた本実施の形態においては、先の図３に示したように、爪部５Ａａ，５Ｂａに設けた補助磁極部２１を、その厚み（図３中左右方向の幅）がほぼ一定となるように形成したが、図４に示すように、その先端側（すなわち図４中下側、言いかえれば回転子１の径方向内側）の幅寸法Ｗ１と比較して、若干、付根側（すなわち図４中上側、言いかえれば回転子１の径方向外側）の幅Ｗ２が相対的に厚くなるように補助磁極部２１'を形成することにより、補助磁極部の機械的強度を向上させることができるとともに、永久磁石７から流入する磁束の流れを円滑化することができる。

【００３９】また、この図４において、つば部２２'には面取りが施されており（ベベルが設けられており）、回転子１の回転する際の各爪部５Ａａ，５Ｂａと固定子鉄心１４との磁気的な断続が円滑になる。これにより固定子２と各爪部５Ａａ，５Ｂａとの間の空隙における磁束脈動が減少するので、磁気的振動を抑制し、騒音を低減させることができる。なお、図４は、先に説明した第１の実施の形態の図３中Ａ部に相当する部分の詳細構造を表す拡大図である。

【００４０】本発明の車両用交流発電機の第２の実施の形態を図５を用いて説明する。図５は、本発明の車両用交流発電機の第２の実施の形態に備えられた爪磁極５Ａ，５Ｂの爪部５Ａａ$_1$，５Ｂａ$_1$と永久磁石７との配置関係を表す図で、先の図３に対応する図である。なお、図３と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図５においても図３と同様、繁雑防止のため爪部５Ａａ$_1$，５Ｂａ$_1$を１極分づつ図示した。繁雑防止のため特に図示しないが、爪部５Ａａ$_1$，５Ｂａ$_1$は、従来のように、上記つば部２２の部分を除き、その回転子１の軸方向（図５中紙面直交方向）の断面形状が先端が細くなるようにほぼ三角形状に形成されている。そして図５に示すように、本実施の形態においては、このような形状の爪部５Ａａ$_1$，５Ｂａ$_1$と永久磁石７との間に、永久磁石７の磁極面全面と接触し、磁性体により構成された補助磁極板２３を介設している。その他の構成は、第１の実施の形態と同様である。

【００４１】本実施の形態においては、上記のように、爪部５Ａａ$_1$，５Ｂａ$_1$と永久磁石７との間に永久磁石７の磁極面全面と接触する補助磁極板２３を介在させることにより、永久磁石７から出た磁束は、ほぼ全てが補助磁極板２３を介して爪形磁極５Ａ，５Ｂに入るので、永久磁石７の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、第１の実施の形態と同様、爪磁極５Ａ，５Ｂ間に配置した永久磁石７の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【００４２】なお、本実施の形態における永久磁石７の着磁の際には、予め永久磁石７の着磁面（図５中左右両面）に補助磁極板２３を接着したものを隣接する爪部５Ａａ$_1$，５Ｂａ$_1$間に配置し、その後外部の着磁ヨーク（図示せず）により着磁する。この着磁は、前にも説明したように、冷却ファン２０ａ，２０ｂ（図１参照）の取付け及びバランス取りを行った後、回転子１の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

【００４３】本発明の車両用交流発電機の第３の実施の形態を図６を用いて説明する。図６は、本発明の車両用

交流発電機の第３の実施の形態に備えられた爪磁極５Ａ，５Ｂの爪部５Ａａ$_2$，５Ｂａ$_2$と永久磁石７との配置関係を表す図で、先の図３に対応する図である。なお、図３と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図６においても図３と同様、繁雑防止のため爪部５Ａａ$_2$，５Ｂａ$_2$を１極分づつ図示した。繁雑防止のため特に図示しないが、爪部５Ａａ$_2$，５Ｂａ$_2$を、その回転子１の径方向内側（図６中下側）の面が、回転子１の径方向外側（図６中上側）の面に対して略平行となるように形成している。すなわち、爪部５Ａａ$_2$，５Ｂａ$_2$の全体の厚みは、先端部から根元部までほぼ同じで、その回転子１の軸方向（図６中紙面直交方向）の断面形状は、ほぼ長方形状に形成されている。

【００４４】このような構造により、永久磁石７の回転子１の周方向（図６中左右方向）側面（磁極面）は、磁性体により構成された爪部５Ａａ$_2$，５Ｂａ$_2$に対し全面密着している。その他の構成は、第１の実施の形態と同様であり、本実施の形態においても、同様の効果を得る。

【００４５】なお、本実施の形態は、例えば建設機械等に用いる車両用交流発電機に好適である。すなわち、爪部５Ａａ$_2$，５Ｂａ$_2$は、先端部を根元部とほぼ同じ厚みで形成したため、先端部の重量が、第１及び第２の実施の形態に用いた爪部５Ａａ，５Ｂａ，５Ａａ$_1$，５Ｂａ$_1$と比較して重いため、回転子１（図１参照）の回転により回転子１の径方向外側（図６中上側）に起き上がる可能性があるが、例えば建設機械等に用いる車両用交流発電機等は、通常３０００～４０００ｒｐｍ程度の比較的小さい回転数で定速回転するため、遠心力に対して爪部５Ａａ$_2$，５Ｂａ$_2$の付け根部分に働く応力が小さく、爪部５Ａａ$_2$，５Ｂａ$_2$が上記のように起き上がる可能性は小さい。また、上記形状の本実施の形態における爪部５Ａａ$_2$，５Ｂａ$_2$においては、永久磁石７から流入する磁束の流れが円滑となるので、高い出力が要求される建設機械等に用いる車両用交流発電機に好適となる。

【００４６】また、この第３の実施の形態の車両用交流発電機を高速回転させる場合、図７に示すように、各爪部５Ａａ$_2$，５Ｂａ$_2$を、例えばその回転子１の径方向内側から略リング状の連結リング２４で連結すればよい。この連結リング２４は、各爪部５Ａａ$_2$，５Ｂａ$_2$に対し、それぞれネジ２５により固定されている（固定方法としては、特にこれに限られず、例えば溶接等により固定してもよい）。このとき、連結リング2.4は非磁性体で、ネジ２５は磁性体で構成することが望ましい。なお、図７では、繁雑防止のため永久磁石７は図示省略している。そして、上記の連結リング２４が、請求項５に記載の略リング状の連結部材を構成する。

【００４７】ここで、永久磁石７の少なくとも回転子１の径方向外側に保護部材として磁石カバーを配置することにより、何らかの理由により永久磁石７が割れてしまった場合、回転子１の回転によりに割れた永久磁石７が回転子１から飛び出すことを防止することができる。以下に、本発明の車両用交流発電機に磁石カバーを設けた変形例を順次説明する。

【００４８】図８は、先に説明した本発明の車両用交流発電機の第１の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａａ，５Ｂａと永久磁石７との配置関係を表す図で、先の図３に対応する図である。なお、図３と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図８においても図３と同様、繁雑防止のため爪部５Ａａ，５Ｂａを１極分づつ図示した。この図８において、永久磁石７の回転子１の径方向外側の面は、これとほぼ同形状の磁石カバー２６と密着している。この磁石カバー２６は、爪磁極５Ａ，５Ｂ間に配置した永久磁石７の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においては、磁石カバー２６が爪部２２に保持されており、このように磁石カバー２６を設けた場合も、永久磁石７の磁極面全面が爪形磁極５Ａ，５Ｂ（厳密には爪部５Ａａ，５Ｂａ）と接触している。

【００４９】図９は、先に説明した本発明の車両用交流発電機の第３の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａａ$_2$，５Ｂａ$_2$と永久磁石７との配置関係を表す図で、先の図６に対応する図である。なお、図６と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図９においても図６と同様、繁雑防止のため爪部５Ａａ$_2$，５Ｂａ$_2$を１極分づつ図示した。この図９においても、先に図８を用いて説明した変形例と同様、永久磁石７の回転子１の径方向外側の面は、これとほぼ同形状の磁石カバー２６と密着している。この磁石カバー２６は、爪磁極５Ａ，５Ｂ間に配置した永久磁石７の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においては、磁石カバー２６が爪部２２に保持されており、このように磁石カバー２６を設けた場合も、永久磁石７の磁極面全面が爪形磁極５Ａ，５Ｂ（厳密には爪部５Ａａ$_2$，５Ｂａ$_2$）と接触している。

【００５０】なお、本変形例においても、先の図７で説明した連結リング２４により各爪部５Ａａ$_2$，５Ｂａ$_2$を連結すれば、回転子１を高速で回転させる場合にも対応できる。

【００５１】以上２つの変形例においても、第１の実施の形態と同様の効果を得ることができるとともに、何らかの理由により永久磁石７が割れてしまった場合、回転子１の回転によりに割れた永久磁石７が回転子１から飛び出すことを防止することができる。

【００５２】また、以上２つの変形例における永久磁石

７の着磁の際には、予め永久磁石７の回転子１の径方向外側の面に磁石カバー２６を接着したものを隣接する爪形磁極５Ａ，５Ｂ間に配置し、その後外部の着磁ヨーク（図示せず）により着磁する。前述したように、この着磁は回転子１の製造工程の最終段階で行うのが望ましく、この場合、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

【００５３】なお、以上２つの変形例においては、板状の磁石カバー２６で永久磁石７の回転子１径方向外側の面を保護する構造としたが、これに限られる必要はない。すなわち、永久磁石７の磁極面以外の面は磁気特性に影響を与えないため、磁石カバーは、例えば磁極面以外の４面を囲んでしまうような形状としてもよく、要は磁石カバーの形状は、その技術的思想を逸脱しない範囲で種々に変形させて構わない。以下に、このような永久磁石７の磁極面以外の４面を囲む磁石カバーを設けた本発明の車両用交流発電機の変形例を図１０及び図１１を用いて説明する。

【００５４】図１０は先に説明した本発明の車両用交流発電機の第２の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａa_1，５Ｂa_1と永久磁石７との配置関係を表す図で、先の図５に対応する図である。図１１はこの磁石カバーの全体構造を表す斜視図である。なお、図１０において、図５と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図１０においても図５と同様、繁雑防止のため爪部５Ａa_1，５Ｂa_1を１極分づつ図示した。これら図１０及び図１１に示すように、磁石カバー２６Ａは永久磁石７の磁極面以外の４面を囲むような枠形形状で、永久磁石７の磁極面以外の４面と極力密着するように、その内周側壁面は精度よく加工されている。また、この磁石カバー２６Ａも、爪磁極５Ａ，５Ｂ間に配置した永久磁石７の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においても、磁石カバー２６Ａが爪部２２に保持されており、このように磁石カバー２６Ａを設けた場合も、永久磁石７の磁極面全面が爪形磁極５Ａ，５Ｂ（厳密には爪部５Ａa_1，５Ｂa_1）と接触している。

【００５５】本変形例においても、第１の実施の形態と同様の効果を得ることができるとともに、何らかの理由により永久磁石７が割れてしまった場合、回転子１の回転によりに割れた永久磁石７が回転子１から飛び出すことを防止することができる。

【００５６】なお、本実施の形態における永久磁石７の着磁の際には、まず、枠状に形成された磁石カバー２６Ａの内周側に未着磁の永久磁石７を差し込み、この状態で永久磁石７の磁極面に補助磁極板２３，２３を配置する。図１０からも分かるように、補助磁極板２３の寸法

は、磁石カバー２６Ａの回転子１の周方向（図１０中左右方向）側面とほぼ同一で、永久磁石７は、磁石カバー２６Ａと補助磁極板２３，２３とを例えば溶接等により接続して構成された箱の内壁面に精度よく収まっている。

【００５７】そして、磁石カバー２６Ａ、補助磁極板２３，２３、及び永久磁石７を一体的に組立てた状態で、これを補助磁極板２３，２３が爪部５Ａa_1，５Ｂa_1と接触するように、隣接する爪部５Ａa_1，５Ｂa_1間に配置し、その後外部の着磁ヨーク（図示せず）により着磁する。この着磁も前述と同様、回転子１の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

【００５８】以上３つの変形例において、上記磁石カバー２６，２６Ａが、請求項９に記載の保護部材を構成する。

【００５９】また、上記した磁石カバー２６，２６Ａは、先に説明した第１～第３の実施の形態と、任意に組合せ可能であることは言うまでもない。

【００６０】またここで、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等、永久磁石と接触する部分に永久磁石を機械的に保持する磁石保持部を設けることにより、未着磁時の永久磁石が爪磁極間から脱落することを防止でき、回転子の組立作業、永久磁石の着磁作業等の作業性を向上させることができる。以下に、本発明の車両用交流発電機に磁石保持部を設けた変形例を順次説明する。

【００６１】図１２は、先に説明した本発明の車両用交流発電機の第１の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａa_3，５Ｂa_3と永久磁石７との配置関係を表す図で、先の図３に対応する図である。なお、図３と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図１２においても図３と同様、繁雑防止のため爪部５Ａa_3，５Ｂa_3を１極分づつ図示した。この図１２に示すように、本変形例においては、各補助磁極部２１Ａの回転子１の径方向内側（図１２中下側）端部には、それぞれ磁石保持部２１Ａａが、爪部２２との間に永久磁石７を挟み込むように設けられている。このように磁石保持部２１Ａａを設けた場合も、永久磁石７の磁極面全面が爪形磁極５Ａ，５Ｂ（厳密には爪部５Ａa_3，５Ｂa_3）と接触している。その他の構成は第１の実施の形態と同様である。なお、本変形例の磁石保持部２１Ａａは、先に説明した第３の実施の形態にも適用可能であることは言うまでもない。

【００６２】図１３は、先に説明した本発明の車両用交流発電機の第２の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａa_1，５Ｂa_1と永久磁石７との配置関係を表す図で、先の図５に

対応する図である。なお、図５と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図１３においても図５と同様、繁雑防止のため爪部５Ａa_1，５Ｂa_1を１極分づつ図示した。この図１３に示すように、本変形例においては、各補助磁極板２３Ａの回転子１の径方向内側（図１３中下側）端部には、それぞれ磁石保持部２３Ａａが、爪部２２との間に永久磁石７を挟み込むように設けられている。このように磁石保持部２３Ａａを設けた場合も、永久磁石７の磁極面全面が補助磁極板２３Ａと接触している。その他の構成は第２の実施の形態と同様である。

【００６３】図１４は、先に説明した本発明の車両用交流発電機の第２の実施の形態に磁石保持部を設けた他の変形例に備えられた爪磁極５Ａ，５Ｂの爪部５Ａa_1，５Ｂa_1と永久磁石７との配置関係を表す図で、先の図５に対応する図である。なお、図５と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図１４においても図５と同様、繁雑防止のため爪部５Ａa_1，５Ｂa_1を１極分づつ図示した。この図１４に示すように、本変形例においては、各補助磁極板２３Ｂの回転子１の径方向内側（図１３中下側）及び外側（図１３中上側）端部には、それぞれ磁石保持部２３Ｂａ，２３Ｂｂが、永久磁石７を挟み込むように設けられている。そして、爪部２２により、磁石保持部２３Ｂｂは保持されている。このように磁石保持部２３Ｂａ，２３Ｂｂを設けた場合も、永久磁石７の磁極面全面が補助磁極板２３Ｂと接触している。その他の構成は第２の実施の形態と同様である。

【００６４】なお、図１３及び図１４を用いて説明した２つの本変形例における永久磁石７の着磁の際には、予め永久磁石７の着磁面（図１３及び図１４中左右両面）に補助磁極板２３Ａ，２３Ｂを接着したものを隣接する爪部５Ａa_1，５Ｂa_1間に配置し、その後外部の外部の着磁ヨーク（図示せず）により着磁する。この着磁も、前述と同様、回転子１の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。また特に、図１４で説明した変形例においては、補助磁極板２３Ｂの図中上下方向の形状がほぼ同様であるため、永久磁石７の着磁面に補助磁極板２３Ｂを接着したものを爪形磁極５Ａ，５Ｂ間に配置する際、その上下方向の向きを気にしなくてもよく、作業性が向上する。

【００６５】以上３つの変形例においても、先の第１の実施の形態と同様の効果が得られるとともに、未着磁時の永久磁石７が爪磁極５Ａ，５Ｂ間から界磁巻線６側に脱落することを防止でき、回転子１の組立作業、永久磁石７の着磁作業等の作業性を向上させることができる。

【００６６】なお、実際には加工公差、面粗度等により厳密に永久磁石の磁極面全面と接触するように、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等を形成することは難しく、ミクロ的に見た場合、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等と永久磁石の磁極面全面とは、完全に接触していない（ほぼ覆っているにとどまる）可能性もあるが、これらのような場合も、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等と、永久磁石の磁極面全面とは、事実上ほぼ接触していると考えることができ、ほぼ同様の効果を得ることができる。

【００６７】また、先の図４を用いて説明した補助磁極部２１'の強度補強及び磁束の流れの円滑化、つば部２２'の騒音低減の構造は、以上説明してきた各実施の形態及び変形例にも適用可能であることは言うまでもない。

【００６８】さらに、以上は、回転する界磁巻線６に対し、ブラシ１３ａ，１３ｂを設けて電力を供給する型の車両用交流発電機を例にとって説明したが、例えば界磁巻線が固定されたブラシレスタイプの車両用交流発電機等に対しても、本発明は適用可能であり、要は爪磁極間に永久磁石を配置するもので有れば同様の効果が得られることは言うまでもない。

【００６９】また、永久磁石７が回転子１の回転等により回転子１外に飛び出すことを防止する構造としては、つば部２２，２２'等を設ける構造としたが、これに限られず、例えば爪部の回転子周方向の幅寸法を、回転子径方向内側よりも外側を広くし、その回転子周方向の幅寸法を、回転子径方向外側よりも内側を広く形成した台形状の永久磁石を爪部間に配置する構造とすれば、つば部２２，２２'は省略することもできる。

【００７０】

【発明の効果】請求項１に記載の発明によれば、爪形磁極の爪部を永久磁石の磁極面全面と接触するように形成することにより、永久磁石から出た磁束は、ほぼ全てが爪部に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【００７１】請求項７に記載の発明によれば、爪部と永久磁石との間に永久磁石の回転子の磁極面全面と接触する補助磁極板を介在させることにより、永久磁石から出た磁束は、ほぼ全てが補助磁極板を介して爪形磁極に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【図面の簡単な説明】

【図１】本発明の車両用交流発電機の第１の実施の形態の全体構造を表す断面図である。

【図２】本発明の車両用交流発電機の第１の実施の形態に備えられた爪部の詳細構造を表す側面図である。

【図３】本発明の車両用交流発電機の第１の実施の形態に備えられた爪部と永久磁石との配置関係を表す図で、図１中III－III断面による断面図である。

【図４】本発明の車両用交流発電機の第１の実施の形態に備えられた補助磁極部の補強及び磁束の流れの円滑化、騒音低減の構造を設けた変形例の構造を表す図で、図３中Ａ部に相当する部分の拡大図である。

【図５】本発明の車両用交流発電機の第２の実施の形態に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図３に対応する図である。

【図６】本発明の車両用交流発電機の第３の実施の形態に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図３に対応する図である。

【図７】本発明の車両用交流発電機の第３の実施の形態に備えられた各爪部を連結リングで連結した変形例の詳細構造を表す斜視図である。

【図８】本発明の車両用交流発電機の第１の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図３に対応する図である。

【図９】本発明の車両用交流発電機の第３の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図６に対応する図である。

【図１０】本発明の車両用交流発電機の第２の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図５に対応する図である。

【図１１】図１０に示した磁石カバーの全体構造を表す斜視図である。

【図１２】本発明の車両用交流発電機の第１の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図３に対応する＊図である。

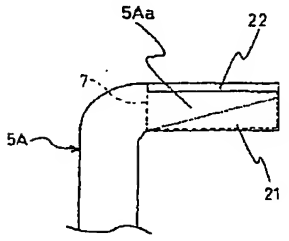
【図１３】本発明の車両用交流発電機の第２の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図５に対応する図である。

【図１４】本発明の車両用交流発電機の第２の実施の形態に磁石保持部を設けた他の変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図５に対応する図である。

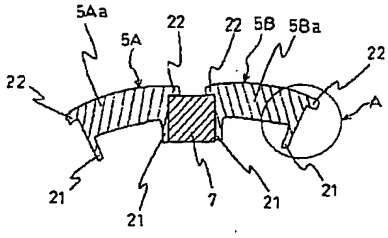
【符号の説明】

1	回転子
2	固定子
5A，B	爪形磁極
5Aa，Ba	爪部
$5Aa_1$，Ba_1	爪部
$5Aa_2$，Ba_2	爪部
$5Aa_3$，Ba_3	爪部
6	界磁巻線
7	永久磁石
14	固定子鉄心
15	固定子巻線
21	補助磁極部
21'	補助磁極部
21A	補助磁極部
21Aa	磁石保持部
23	補助磁極板
23A，B	補助磁極板
23Aa	磁石保持部
23Ba，b	磁石保持部
24	連結リング（連結部材）
26	保護部材（保護カバー）
26A	保護部材（保護カバー）

【図２】

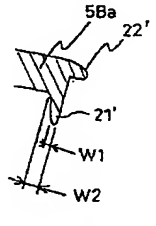


【図３】



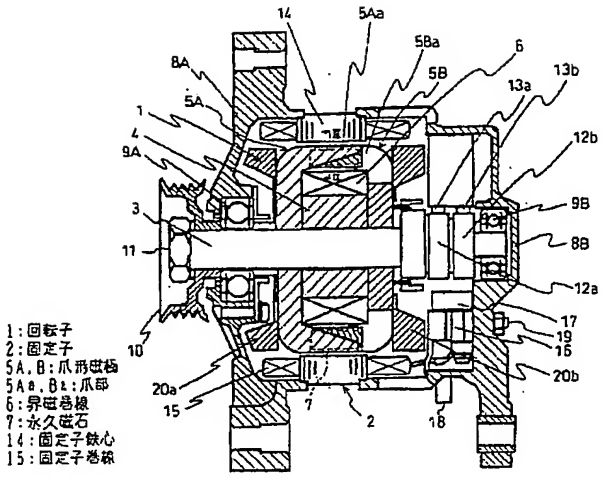
5A，B：爪形磁極
5Aa，Ba：爪部
21：補助磁極部

【図４】

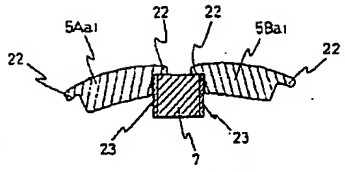


21'：補助磁極部

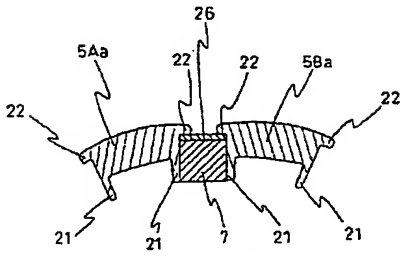
【図１】



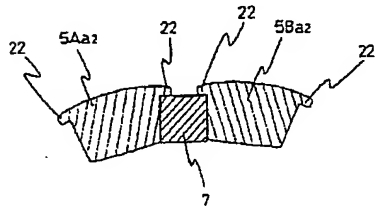
【図５】



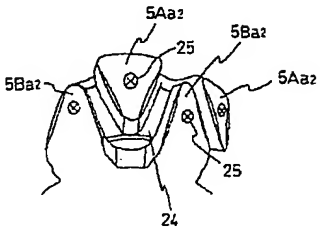
【図８】



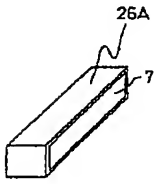
【図６】



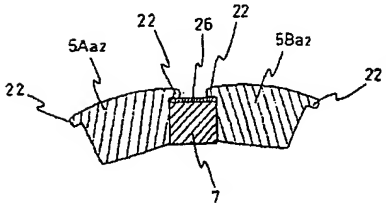
【図７】



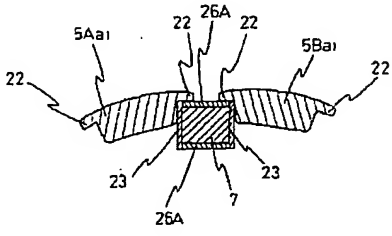
【図１１】



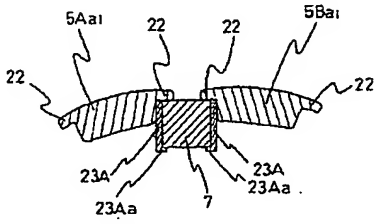
【図９】



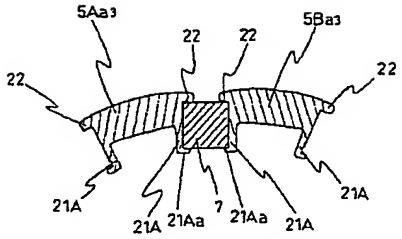
【図１０】



【図１３】

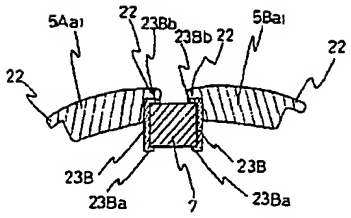


【図１２】



5Aa3, Ba3：爪部
21A：補助磁極部
21Aa：磁石保持部

【図１４】



5Aa1, Ba1：爪部
23B：補助磁極板
23Ba, b：磁石保持部

【手続補正書】
【提出日】平成１３年５月１６日（２００１．５．１６）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】０００３
【補正方法】変更
【補正内容】
【０００３】このような構造により、Ｎ極に磁化した爪形磁極から出た磁束は、固定子鉄心を介してＳ極に磁化した爪形磁極に戻る磁気回路を形成し、この磁気回路の磁束が固定子の固定子巻線に鎖交し、また回転子が回転することにより、固定子巻線に交流の誘起電圧が発生するようになっている。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】００３０　　＊
＊【補正方法】変更
【補正内容】
【００３０】次に上記構成の本実施の形態の車両用交流発電機の動作について説明する。上記のように、まず、例えば図示しないエンジン等から動力を受けて回転する回転子１の界磁巻線６に、ブラシ１３ａ，１３ｂ及びスリップリング１２ａ，１２ｂを介して電力が供給され、回転子１の爪形磁極５ＡがＳ極に、爪形磁極５ＢがＮ極に磁化される。Ｎ極に磁化した爪形磁極５Ｂから出た磁束は、固定子２において、固定子鉄心１４を介してＳ極に磁化した爪形磁極５Ａに戻る磁気回路を形成する。このとき、界磁巻線６が作る磁気回路は、補助励磁用の永久磁石７の磁束が加わることにより増磁される。そして、この磁気回路の磁束は、固定子巻線１５に鎖交し、回転子１の回転により固定子鉄心１５に３相に巻回された固定子巻線１５に交流の誘起電圧が発生する。

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5H622 AA03 CA02 CA10 CB01 DD02 PP03 PP17 QB08

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(19) United States

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(54) VEHICULAR ALTERNATOR

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(21) Appl. No.: **09/941,655**

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Feb. 27, 2001 (JP) 2001-053017

Publication Classification

(51) **Int. Cl.**[7] **H02K 1/22**

(52) **U.S. Cl.** **310/263**

(57) **ABSTRACT**

A vehicular alternator is provided which can effectively utilize the magnetic flux of a permanent magnet disposed between claw-type magnetic poles and can improve an output of the alternator. The vehicular alternator comprises a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws. Each of the plurality of claws of the rotor is formed to have a shape coming into contact with the whole of a magnetic pole surface of the permanent magnet.

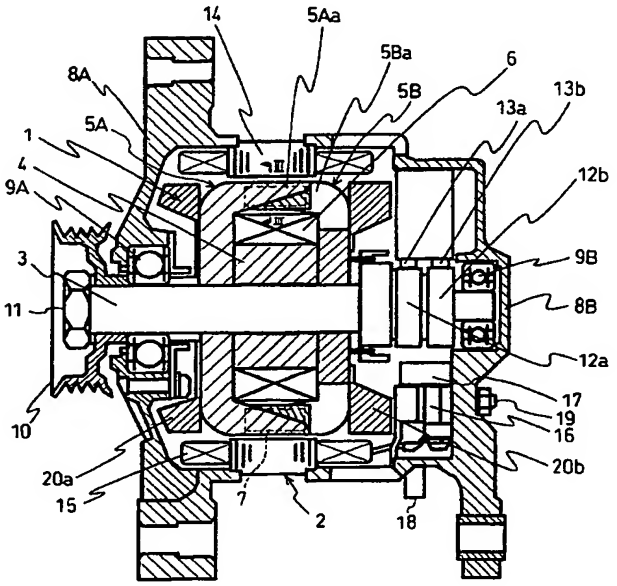


FIG. 1

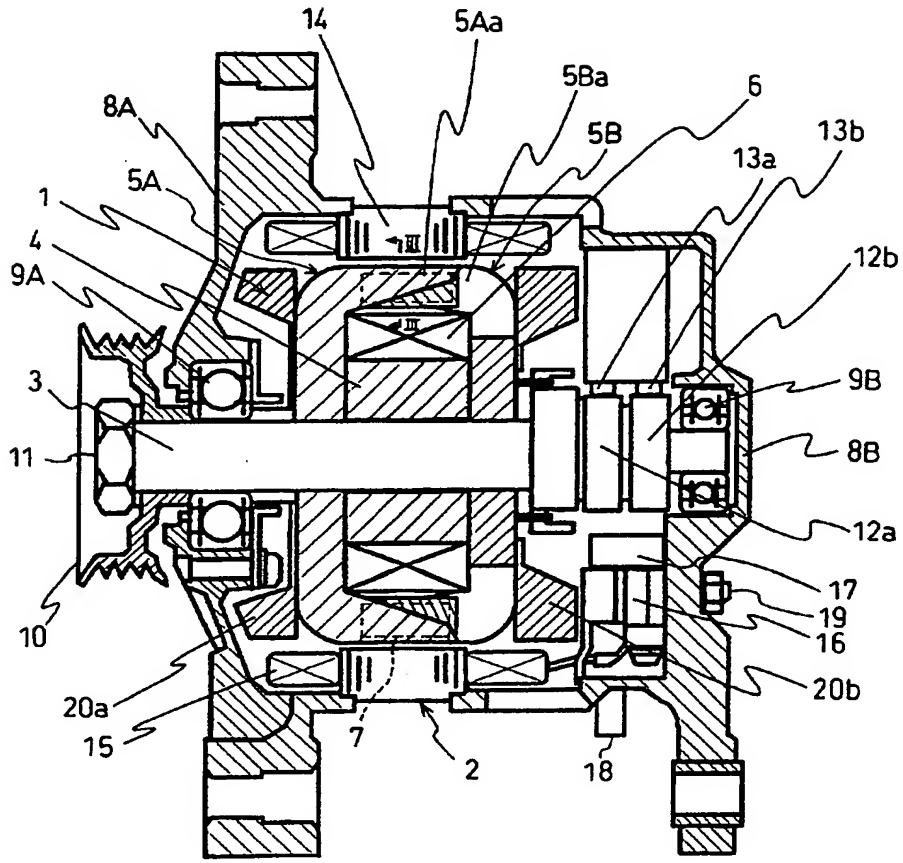

14
5Aa
5Ba
6
8A
5B
13b
13a
5A
1
4
9A
12b
3
9B
11
8B
12a
17
19
16
10
20b
20a
15
7
2
18

FIG.2

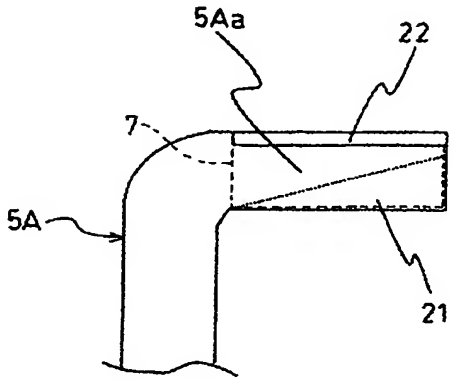


FIG.3

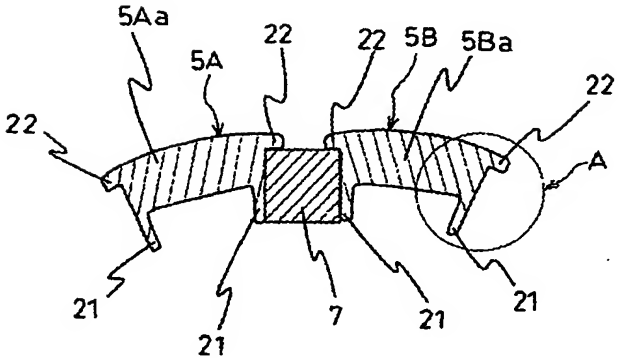


FIG.4

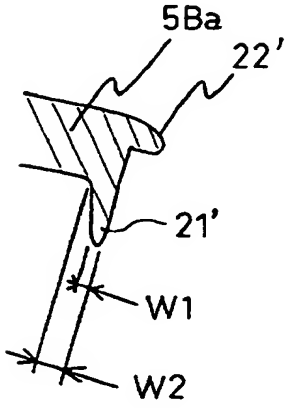


FIG.5

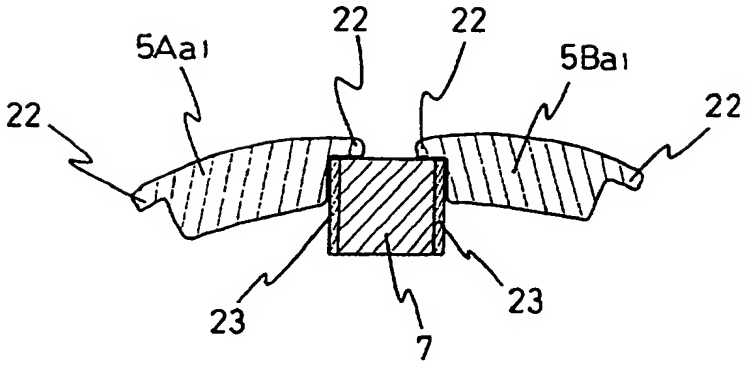


FIG.6

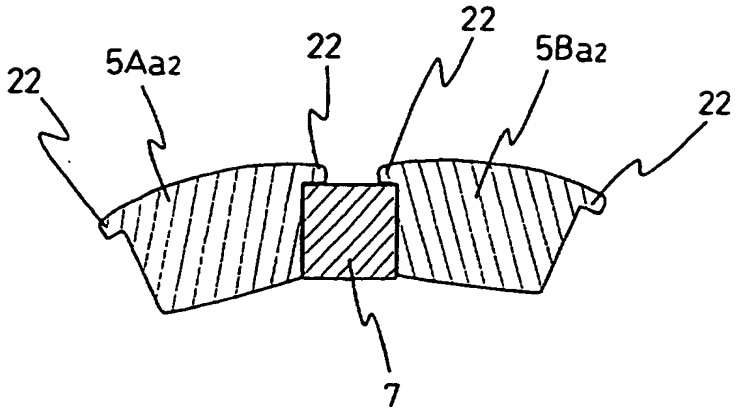


FIG.7

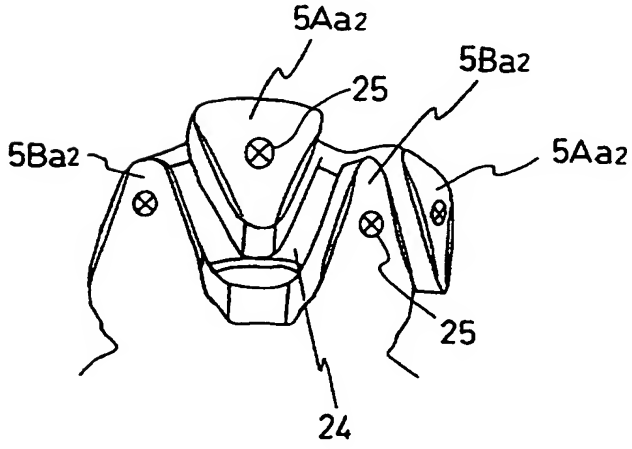


FIG.8

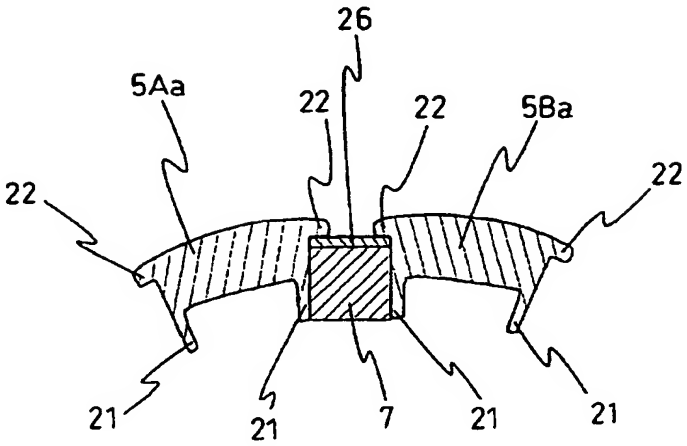


FIG.9

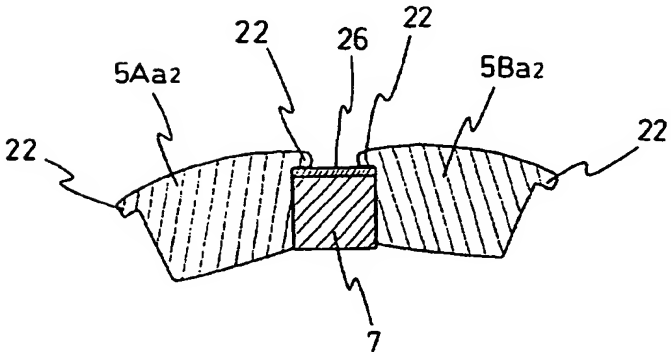


FIG. 10

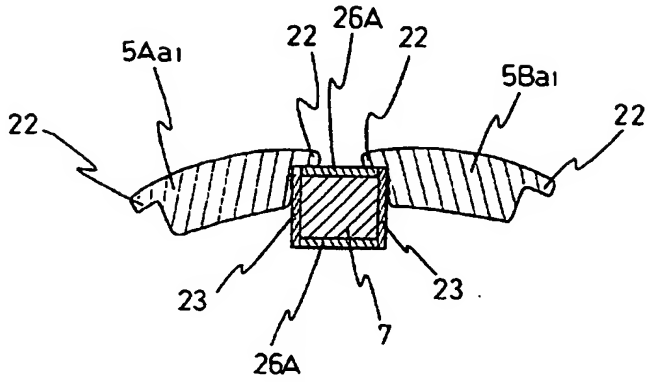


FIG. 11

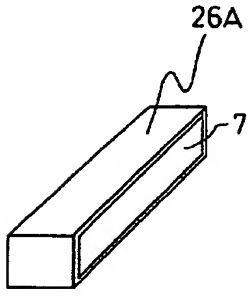


FIG. 12

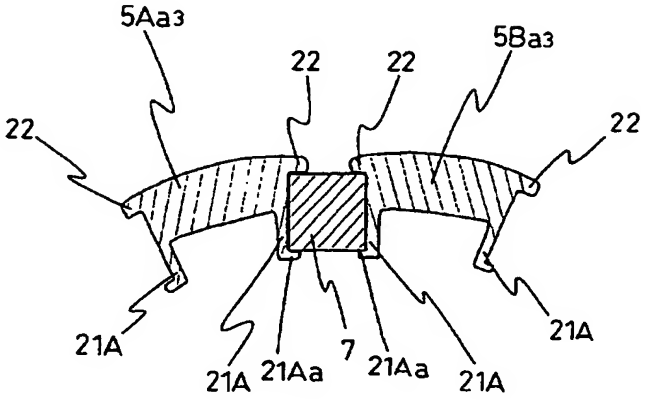

5Aa3
22
22
5Ba3
22
22
21A
21A
21Aa
7
21Aa
21A
21A

FIG. 13

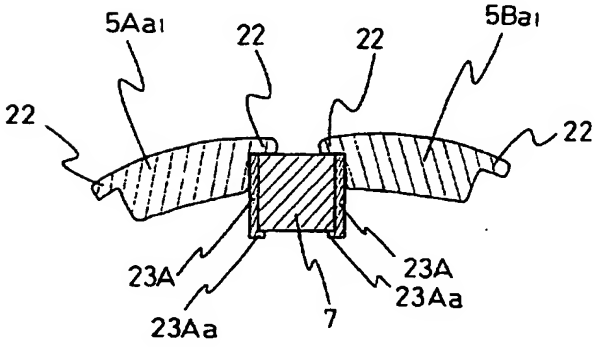
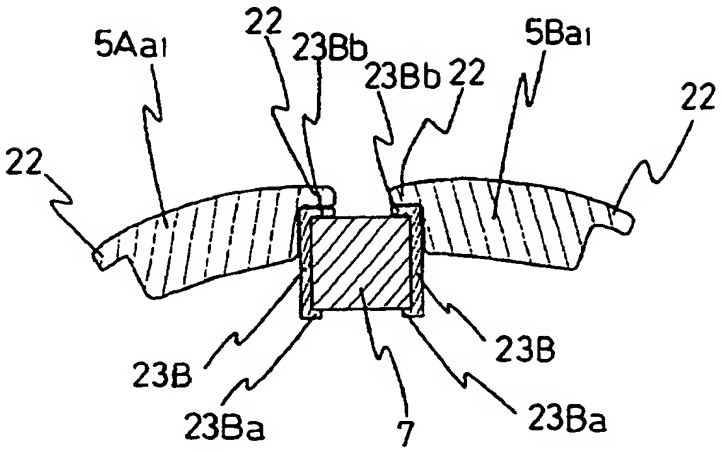

5Aa1
22
22
5Ba1
22
22
23A
23Aa
7
23A
23Aa

FIG. 14



VEHICULAR ALTERNATOR

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a vehicular alternator, and more particularly to a vehicular alternator including a permanent magnet for auxiliary excitation.

[0003] 2. Description of the Related Art

[0004] A vehicular alternator usually comprises a rotor and a stator. In general, the rotor comprises a pair of claw-type magnetic poles arranged in an opposed relation, and field windings coiled radially inward of a plurality of claws provided in each of the claw-type magnetic poles. When a current is supplied to the field windings, the pair of claw-type magnetic poles are magnetized to N and S poles. Also, the stator is constituted by coiling stator windings, from which an AC induced voltage is outputted, over a stator core. The rotor is rotated relative to the stator.

[0005] With such a structure, a magnetic circuit is formed in which the magnetic flux outgoing from the claw-type magnetic pole magnetized to an N pole returns to the claw-type magnetic pole magnetized to an S pole through the stator windings. The magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings of the stator, while the rotor rotates relative to the stator. As a result, an AC induced voltage is generated in the stator windings.

[0006] In the vehicular alternator having the above-described structure, efforts to reduce the magnetic flux leaked between the claw-type magnetic poles and to intensify the magnetic flux generated from the field windings for an increase in output of the alternator have been made, for example, by interposing a permanent magnet for auxiliary excitation between the claw-type magnetic poles. JP,A 11-318064, for example, discloses such a vehicular alternator including a permanent magnet for auxiliary excitation disposed between the claw-type magnetic poles.

[0007] The above-mentioned related are, however, has the following problem.

[0008] Usually, claws of a claw-type magnetic pole are each formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip, for the purpose of reducing the weight of a claw end portion. This is because the claws of the claw-type magnetic pole are cantilevered. In other words, such a sectional shape is intended to prevent the claw end portion from rising radially outward of the rotor due to centrifugal forces when the rotor rotates at high speeds. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each lateral surface (i.e., magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor does not contact the claw, thus resulting in increased resistance against a flow of magnetic flux (i.e., greater magnetic loss) in a magnetic circuit formed by the permanent magnet. Accordingly, the magnetic flux of the permanent magnet is not effectively utilized.

[0009] In the above-described related art, each claw is likewise formed into a substantially triangular shape in section taken along the axial direction of the rotor such that the claw is tapered toward its tip. Although the related art employs a permanent magnet having a relatively small thickness in the radial direction of the rotor, a particular consideration is not focused on the shape of a contact surface between the claw and the permanent magnet. Hence, a part of a magnetic pole surface of the permanent magnet not contacting the claw also occurs near a claw end portion, and effective utilization of the magnetic flux of the permanent magnet is not ensured.

SUMMARY OF THE INVENTION

[0010] Accordingly, it is an object of the present invention to provide a vehicular alternator, which can effectively utilize the magnetic flux of a permanent magnet disposed between claw-type magnetic poles and can improve an output of the alternator.

[0011] (1) To achieve the above object, the present invention provides a vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws, wherein each of the plurality of claws of the rotor is formed to have a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet.

[0012] As described above in connection with the related art, claws of a claw-type magnetic pole are each usually formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each lateral surface (magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor does not contact the claw. Thus, the resistance against a flow of magnetic flux (i.e., magnetic loss) in a magnetic circuit formed by the permanent magnet is increased and the magnetic flux of the permanent magnet is not effectively utilized.

[0013] To overcome that problem, according to one aspect of the present invention, the claws of the claw-type magnetic poles are each formed to a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet in the circumferential direction of the rotor. This feature enables almost all of the magnetic flux outgoing from the permanent magnet to flow into the claws, thus resulting in reduced resistance against a flow of the magnetic flux (i.e., smaller magnetic loss) in the magnetic circuit formed by the permanent magnet. As a result, the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles can be effectively utilized, and the output of the vehicular alternator can be increased.

[0014] (2) In above (1), preferably, each of the plurality of claws has an auxiliary magnetic pole portion contacting the whole of the magnetic pole surface of the permanent magnet.

[0015] (3) In above (2), preferably, the auxiliary magnetic pole portion is formed to have a greater width on the outer side in the radial direction of the rotor than on the inner side in the radial direction of the rotor.

[0016] (4) In above (1), preferably, each of the plurality of claws is formed such that an inner surface of each claw in the radial direction of the rotor is substantially parallel to an outer surface thereof in the radial direction of the rotor.

[0017] (5) In above (4), preferably, the plurality of claws are interconnected by a substantially ring-shaped coupling member.

[0018] (6) In any of above (1) to (5), more preferably, each of the plurality of claws has a magnet holding portion for holding the permanent magnet.

[0019] (7) Also, to achieve the above object, the present invention provides a vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws, wherein an auxiliary magnetic pole plate contacting the whole of a magnetic pole surface of the permanent magnet is interposed between each of the plurality of claws and the permanent magnet.

[0020] Thus, according to another aspect of the present invention, the auxiliary magnetic pole plate contacting the whole of a lateral surface (magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor is interposed between each claw and the permanent magnet. This arrangement enables almost all of the magnetic flux outgoing from the permanent magnet to flow into the claws, thus resulting in reduced resistance against a flow of the magnetic flux (i.e., smaller magnetic loss) in the magnetic circuit formed by the permanent magnet. As a result, the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles can be effectively utilized, and the output of the vehicular alternator can be increased.

[0021] (8) In above (7), preferably, the auxiliary magnetic pole plate has a magnet holding portion for holding the permanent magnet.

[0022] (9) In any of above (1) to (8), more preferably, a protective member is disposed at least on the outer side of the permanent magnet in the radial direction of the rotor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] **FIG. 1** is a sectional view showing an overall structure of a first embodiment of a vehicular alternator according to the present invention;

[0024] **FIG. 2** is a side view showing a detailed structure of a claw provided in the first embodiment of the vehicular alternator according to the present invention;

[0025] **FIG. 3** is a sectional view, taken along line III-III in **FIG. 1**, showing the positional relationship between claws and a permanent magnet provided in the first embodiment of the vehicular alternator according to the present invention;

[0026] **FIG. 4** is a partial enlarged view corresponding to a part A in **FIG. 3**, showing a structure of a modification in which an auxiliary magnetic pole portion provided in the vehicular alternator of the first embodiment according to the present invention is modified with intent to realize reinforcement of the strength, to promote a smooth flow of magnetic flux, and to reduce noise;

[0027] **FIG. 5** is a sectional view corresponding to **FIG. 3**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a second embodiment of the vehicular alternator according to of the present invention;

[0028] **FIG. 6** is a sectional view corresponding to **FIG. 3**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a third embodiment of the vehicular alternator according to the present invention;

[0029] **FIG. 7** is a perspective view showing a detailed structure of a modification of the third embodiment of the vehicular alternator according to the present invention, in which the claws are interconnected by a coupling ring;

[0030] **FIG. 8** is a sectional view corresponding to **FIG. 3**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the first embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0031] **FIG. 9** is a sectional view corresponding to **FIG. 6**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the third embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0032] **FIG. 10** is a sectional view corresponding to **FIG. 5**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0033] **FIG. 11** is a perspective view showing an overall structure of the magnet cover shown in **FIG. 10**;

[0034] **FIG. 12** is a sectional view corresponding to **FIG. 3**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the first embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided;

[0035] **FIG. 13** is a sectional view corresponding to **FIG. 5**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided; and

[0036] **FIG. 14** is a sectional view corresponding to **FIG. 5**, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided

in another modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Embodiments of the present invention will be described with reference to the drawings.

[0038] FIG. 1 is a sectional view showing an overall structure of a first embodiment of a vehicular alternator according to the present invention.

[0039] Referring to FIG. 1, the vehicular alternator of this embodiment mainly comprises a rotor 1 and a stator 2. The rotor 1 comprises a shaft (rotary shaft) 3; a yoke 4 having the center of rotation through which the shaft 3 is inserted; a pair of claw-type magnetic poles 5A, 5B each made of a magnetic substance and having the center of rotation through which the shaft 3 is inserted, the claw-type magnetic poles 5A, 5B being arranged in an opposed relation through the yoke 4 with a predetermined spacing held between them in the axial direction of the rotor 1 (left-and-right direction in FIG. 1); and field windings 6 coiled over the yoke 4.

[0040] The claw-type magnetic poles 5A, 5B are provided with a plurality of claws 5Aa, 5Ba, respectively. Looking in the circumferential direction of the rotor 1, as shown in FIG. 1, the claws 5Aa, 5Ba are disposed to project alternately in the axial direction of the rotor 1 (left-and-right direction in FIG. 1) in an overlapped relation. A permanent magnet 7 for auxiliary excitation is interposed between two adjacent claws 5Aa, 5Ba in the circumferential direction of the rotor 1. Further, the field windings 6 coiled over the yoke 4 are positioned inward of the claws 5Aa, 5Ba in the radial direction of the rotor 1 with a predetermined space gap left therebetween.

[0041] The shaft 3 is rotatably supported with respect to an alternator body, which comprises end brackets 8A, 8B, by a bearing 9A at a position near an end on one side (left side in FIG. 1) and a bearing 9B at a position near an end on the other side (right side in FIG. 1). Also, a pulley 10 is fixed by a bolt 11 to the end of the shaft 3 on one side (left side in FIG. 1), and slip rings 12*a*, 12*b* are provided near the end of the shaft 3 on the other side (right side in FIG. 1). Additionally, the pulley 10 is coupled by a belt or the like to, for example, a crank pulley of an engine (not shown).

[0042] Inside the end bracket 8B, brushes 13*a*, 13*b* are provided in slide contact with outer circumferences of the slip rings 12*a*, 12*b*. A current is supplied to the field windings 6 of the rotor 1 during rotation thereof through the brushes 13*a*, 13*b* and the slip rings 12*a*, 12*b*. By supplying a current to the field windings 6, the claw-type magnetic pole 5A of the rotor 1 is magnetized to an S pole and the claw-type magnetic pole 5B is magnetized to an N pole.

[0043] The stator 2 comprises a stator core 14 sandwiched between the end brackets 8A, 8B and positioned outward of the claws 5Aa, 5Ba in the radial direction of the rotor 1 (on the upper and lower sides in FIG. 1) with small gaps left relative to the claws 5Aa, 5Ba; and three-phase stator windings 15 coiled over the stator core 14 for outputting an AC induced voltage from them. The rotor 1 is rotated relative to the stator 2. With the stator 2 having the above-described structure, a magnetic circuit is formed in which the magnetic flux outgoing from the claw-type magnetic pole 5B magnetized to an N pole returns to the claw-type magnetic pole 5A magnetized to an S pole through the stator core 14. The magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings 15, while the rotor 1 rotates relative to the stator 2. As a result, an AC induced voltage is generated in the stator windings 15.

[0044] A rectifying circuit 16 and a voltage adjuster 17 are provided inside the end bracket 8B. The rectifying circuit 16 has a battery terminal 18 connected to a positive electrode of a battery (not shown) and a grounding terminal 19 connected to a negative electrode of the battery (not shown). The rectifying circuit 16 rectifies the AC induced voltage, which is generated in the stator windings 15 as described above, for conversion into a DC voltage. The voltage adjuster 17 controls the current supplied to the field windings 6 depending on a load current and the number of revolutions of the rotor 1 so that the DC voltage rectified by the rectifying circuit 16 is kept at a constant voltage of, e.g., about 14.5 V, for thereby charging the battery (not shown).

[0045] Cooling fans 20*a*, 20*b* for air-cooling the stator 2 and the rectifying circuit 16 are provided on both sides of the rotor 1 in the axial direction thereof (left-and-right direction in FIG. 1). The cooling fans 20*a*, 20*b* produces cooling air at a flow rate in proportion to the number of revolutions of the rotor 1.

[0046] In this embodiment thus constructed, the most important feature of the present invention resides in that the claws 5Aa, 5Ba of the rotor 1 are each formed to have a shape coming into contact with the whole of the lateral surface (i.e., magnetic pole surface) of the permanent magnet 7 in the circumferential direction of the rotor 1.

[0047] FIG. 2 is a side view showing a detailed structure of the claw 5Aa, and FIG. 3 is a sectional view, taken along line III-III in FIG. 1, showing the positional relationship between the claws 5Aa, 5Ba and the permanent magnet 7. For the sake of brevity, FIG. 3 shows only one pole constituted by each of the claws 5Aa, 5Ba.

[0048] More specifically, as shown in FIGS. 2 and 3, the claws 5Aa, 5Ba are each formed into a substantially triangular shape in section taken along the axial direction of the rotor 1 (left-and-right direction in FIG. 2), as indicated by dotted line in FIG. 2 similarly to the related art, such that the claw 5Aa, for example, is tapered toward its tip (to the right in FIG. 2), except for both lateral ends of each claw in the circumferential direction of the rotor 1. The permanent magnet 7 is formed to have substantially rectangular lateral surfaces (i.e., magnetic pole surfaces) in the circumferential direction of the rotor 1 (left-and-right direction in FIG. 3). Then, as described above, the permanent magnet 7 is interposed between the claws 5Aa, 5Ba overlapping with each other in the axial direction of the rotor 1 (left-and-right direction in FIG. 2).

[0049] In addition, auxiliary magnetic pole portions 21 are provided at both the lateral ends of each of the claws 5Aa, 5Ba (end surfaces of the claws 5Aa, 5Ba facing each other in an overlapped relation) in the circumferential direction of the rotor 1 (left-and-right direction in FIG. 3) so as to project inward for contact with the whole of the magnetic pole surfaces of the permanent magnet 7. In this embodiment, each auxiliary magnetic pole portion 21 is formed into

substantially the same shape as the corresponding magnetic pole surface of the permanent magnet **7** so that the auxiliary magnetic pole portion **21** is brought into close contact with the permanent magnet **7**. Further, projecting flanges **22** are provided at both the lateral ends of each of the claws **5**Aa, **5**Ba in the circumferential direction of the rotor **1** (left-and-right direction in **FIG. 3**) so as to project circumferentially from outermost portions of both the lateral ends of each claw in the radial direction of the rotor **1** (upper side in **FIG. 3**). The flanges **22** serve to prevent the permanent magnet **7** from ejecting outward due to the rotation of the rotor **1**.

[0050] The operation of the thus-constructed vehicular alternator of this embodiment will be described below.

[0051] First, a current is supplied through the brushes **13***a*, **13***b* and the slip rings **12***a*, **12***b* to the field windings **6** of the rotor **1** that is rotated upon receiving motive power from, e.g., the engine (not shown). With the supply of a current, as described above, the claw-type magnetic pole **5**A of the rotor **1** is magnetized to an S pole and the claw-type magnetic pole **5**B is magnetized to an N pole. A magnetic circuit is thereby formed in which the magnetic flux outgoing from the claw-type magnetic pole **5**B magnetized to an N pole returns to the claw-type magnetic pole **5**A magnetized to an S pole through the stator core **14** in the stator **2**. At that time, the magnetic flux of the magnetic circuit formed by the field windings **6** is intensified by addition of the magnetic flux of the permanent magnet **7** for auxiliary magnetization. Furthermore, the magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings **15**. As a result, with the rotation of the rotor **1** an AC induced voltage is generated in the 3-phase stator windings **15** coiled over the stator core **14**.

[0052] The generated voltage is rectified by the rectifying circuit **16** for conversion into a DC voltage, and then finally charged in the battery (not shown). For charging the battery (not shown) with the DC voltage rectified by the rectifying circuit **16**, the voltage adjuster **17** controls the current supplied to the field windings **6** depending on a load current and the number of revolutions of the rotor **1** so that the generated voltage is kept at a constant voltage of, e.g., about 14.5 V.

[0053] Advantages obtainable with the operation of this embodiment will be described below.

[0054] (1) Higher Output

[0055] Usually, claws of a claw-type magnetic pole are each formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each magnetic pole surface of the permanent magnet does not contact the claw. Thus, the resistance against a flow of magnetic flux (i.e., magnetic loss) in a magnetic circuit formed by the permanent magnet is increased and the magnetic flux of the permanent magnet is not effectively utilized.

[0056] To cope with that problem, in this embodiment, the claws **5**Aa, **5**Ba of the claw-type magnetic poles **5**A, **5**B are each formed to have a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet **7** in the circumferential direction of the rotor **1**, thereby enabling almost all of the magnetic flux outgoing from the permanent magnet **7** to flow into the claws **5**Aa, **5**Ba. It is hence possible to reduce the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet **7** and to effectively utilize the magnetic flux of the permanent magnet. As a result, the output of the vehicular alternator can be increased.

[0057] (2) Lower Cost

[0058] Also, in this embodiment, even in the case of reducing the size of the permanent magnet **7**, the magnetic flux of the permanent magnet **7** can be effectively utilized and the output of the vehicular alternator can be increased because of the advantage of above (1). Consequently, the production cost of the vehicular alternator can be reduced.

[0059] (3) Restraint of Demagnetization at High-Temperatures

[0060] For example, a neodymium magnet is employed as the permanent magnet for auxiliary excitation. The inflection point of an irreversible demagnetization characteristic of such a permanent magnet varies when temperature rises. If the permeance factor is low, therefore, the magnetic density may reduce at high temperatures (called demagnetization at high temperatures). In such a case, when the conventional claw-type magnetic pole is employed which has the claw not contacting the whole of the magnetic pole surface of the permanent magnet, the resistance against a flow of the magnetic flux is increased in the part of the magnetic pole surface of the permanent magnet not contacting the claw of the claw-type magnetic pole, and hence the permeance factor is partly lowered.

[0061] Comparing a working point of a permanent magnet having both magnetic poles not in contact with a magnetic substance and a working point of a permanent magnet having both magnetic poles in contact with a magnetic substance, the latter permanent magnet having both magnetic poles in contact with a magnetic substance has a higher magnetic density at the working point because the permeance factor is higher at the working point thereof. In this embodiment, since both the magnetic poles of the permanent magnet **7** are entirely held in contact with the claws **5**Aa, **5**Ba (exactly speaking, the auxiliary magnetic pole portions **21**) of the claw-type magnetic poles **5**A, **5**B, the effect of the demagnetization at high temperatures can be minimized and an allowance of the permanent magnet **7** for compensating the demagnetization at high temperatures can be increased.

[0062] (4) Easier Magnetization of Permanent Magnet

[0063] For the purpose of preventing metal dust, such as iron powder, from adhering to the permanent magnet, a process of manufacturing the vehicular alternator generally comprises the steps of arranging each permanent magnet for auxiliary excitation, which is in a not yet magnetized state, between the adjacent claws of the claw-type magnetic poles, adjusting a balance in rotation of a rotor, and magnetizing the permanent magnet through an external magnetizing yoke (not shown), for example, in a final stage of the process for manufacturing the rotor. When applying such a manufacturing process to the vehicular alternator of this embodiment, since both the lateral surfaces of the permanent magnet **7** in the circumferential direction of the rotor **1** are entirely held in contact with the claws **5**Aa, **5**Ba (exactly speaking, the auxiliary magnetic pole portions **21**) of the

claw-type magnetic poles 5A, 5B, magnetic flux can be sufficiently permeated to the permanent magnet 7 in the not yet magnetized state, and hence the operation of magnetizing the permanent magnet 7 can be facilitated.

[0064] In this embodiment described above, as shown in FIG. 3, the auxiliary magnetic pole portion 21 provided on each of the claws 5Aa, 5Ba is formed to have a substantially uniform thickness (width in the left-and-right direction in FIG. 3). However, the auxiliary magnetic pole portion 21 may be modified as shown in FIG. 4. Specifically, an auxiliary magnetic pole portion 21' shown in FIG. 4 has a width W2 on the proximal side (on the upper side in FIG. 4, i.e., the outer side in the radial direction of the rotor 1) slightly thicker than a width W1 on the distal side (on the lower side in FIG. 4, i.e., the inner side in the radial direction of the rotor 1). The auxiliary magnetic pole portion 21' having such a shape contributes to increasing the mechanical strength of the auxiliary magnetic pole portion itself and smoothing a flow of the magnetic flux incoming from the permanent magnet 7.

[0065] Further, in the modification of FIG. 4, the flange 22 is replaced by a flange 22' that is beveled at its outermost corner. The beveled flange 22' makes smoother magnetic coupling and decoupling between the claws 5Aa, 5Ba and the stator core 14 during the rotation of the rotor 1. Accordingly, pulsations of the magnetic flux in the space gaps between the stator 2 and the claws 5Aa, 5Ba are reduced. It is hence possible to suppress magnetic vibration and reduce noise.

[0066] Note that FIG. 4 is a partial enlarged view showing a detailed structure of the modification corresponding to a part A in FIG. 3 of the first embodiment.

[0067] A second embodiment of the vehicular alternator of the present invention will be described below with reference to FIG. 5.

[0068] FIG. 5 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in the second embodiment of the vehicular alternator according to the present invention. In FIG. 5, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 5 shows only one pole constituted by each of the claws $5Aa_1$, $5Ba_1$, as with FIG. 3.

[0069] Though not specifically shown for the sake of brevity, the claws $5Aa_1$, $5Ba_1$ are each formed into a substantially triangular shape in section taken along the axial direction of the rotor 1 (direction perpendicular to the drawing sheet of FIG. 5) such that the claw is tapered toward its tip, similarly to the related art, except for the flanges 22. In this embodiment, as shown in FIG. 5, an auxiliary magnetic pole plate 23 made of a magnetic substance is interposed between each of the claws $5Aa_1$, $5Ba_1$ having the shape described above and the permanent magnet 7 such that the plate 23 contacts the whole of a corresponding magnetic pole surface of the permanent magnet 7. The remaining construction is the same as that of the first embodiment.

[0070] Thus, in this embodiment, since the auxiliary magnetic pole plate 23 contacting the whole of the magnetic pole surface of the permanent magnet 7 is interposed between each of the claws $5Aa_1$, $5Ba_1$ and the permanent magnet 7, almost all of the magnetic flux outgoing from the permanent magnet 7 is rendered to flow into the claw-type magnetic poles 5A, 5B through the auxiliary magnetic pole plates 23. It is hence possible to reduce the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet 7. As with the first embodiment, therefore, the magnetic flux of the permanent magnet 7 disposed between the adjacent claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B can be effectively utilized, and the output of the vehicular alternator can be increased.

[0071] When magnetizing the permanent magnet 7 in this embodiment, the auxiliary magnetic pole plates 23 are previously bonded to the surfaces (both left and right side surfaces in FIG. 5) of the permanent magnet 7, which are to be magnetized. The permanent magnet 7 including the auxiliary magnetic pole plates 23 is disposed between two adjacent claws $5Aa_1$, $5Ba_1$, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is preferably magnetized in a final stage of the process for manufacturing the rotor 1 after attaching the cooling fans 20*a*, 20*b* (see FIG. 1) and adjusting a balance in rotation of the rotor. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0072] A third embodiment of the vehicular alternator of the present invention will be described below with reference to FIG. 6.

[0073] FIG. 6 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws $5Aa_2$, $5Ba_2$ of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in the third embodiment of the vehicular alternator according to the present invention. In FIG. 6, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 6 shows only one pole constituted by each of the claws $5Aa_2$, $5Ba_2$ as with FIG. 3.

[0074] In this embodiment, the claws $5Aa_2$, $5Ba_2$ are each formed such that an inner surface (lower side in FIG. 6) of each claw in the radial direction of the rotor 1 is substantially parallel to an outer surface (upper side in FIG. 6) thereof in the radial direction of the rotor 1. In other words, though not specifically shown for the sake of brevity, each of the claws $5Aa_2$, $5Ba_2$ is formed to have a thickness substantially uniform throughout from the distal end to the proximal end, and hence to have a substantially rectangular shape in section taken along the axial direction of the rotor 1 (direction perpendicular to the drawing sheet of FIG. 6).

[0075] Because of the claws $5Aa_2$, $5Ba_2$ having such a structure, both the lateral surfaces (magnetic pole surfaces) of the permanent magnet 7 in the circumferential direction (left-and-right direction in FIG. 6) of the rotor 1 are entirely held in close contact with the claws $5Aa_1$, $5Ba_1$ made of a magnetic substance. The remaining construction is the same as that of the first embodiment. Accordingly, this embodiment can also provide similar advantages to those in the first embodiment.

[0076] Moreover, this embodiment is particularly suitable for a vehicular alternator used in, e.g., construction machines or the likes. Since the claws $5Aa_2$, $5Ba_2$ are each formed to have a thickness substantially uniform throughout from the distal end to the proximal end, the distal end of each claw $5Aa_2$, $5Ba_2$ has greater weight than those of the claws 5Aa, 5Ba, $5Aa_1$ and $5Ba_1$ used in the first and second embodiments. Hence, there is a possibility in this embodiment that the claw distal end may rise outward (upward in FIG. 6) due to the rotation of the rotor 1 (see FIG. 1). In general, however, a vehicular alternator used in, e.g., construction machines or the likes rotates at constant speed with the relatively small number of revolutions in the range of 3000 to 4000 rpm. Therefore, the stresses acting upon root portions of the claws $5Aa_2$, $5Ba_2$ attributable to centrifugal forces are relatively small, thus resulting in a small possibility that the distal ends of the claws $5Aa_2$, $5Ba_2$ rise as mentioned above. On the other hand, the claws $5Aa_2$, $5Ba_2$ each having the above-described shape in this embodiment enable the magnetic flux smoothly to flow into each claw from the permanent magnet 7. This embodiment is hence suitable for the vehicular alternator used in, e.g., construction machines or the likes, which is required to have a higher output.

[0077] Furthermore, in the case of rotating the vehicular alternator of this third embodiment at high speeds, the claws $5Aa_2$, $5Ba_2$ may be interconnected by a coupling ring 24, which is substantially in the form of a ring and fitted to the claws from the inner side in the radial direction of the rotor 1. The coupling ring 24 is fixed to each of the claws $5Aa_2$, $5Ba_2$ by a screw 25 (the fixing method is not limited to the use of screws, and the coupling ring 24 may be fixed by welding, for example). In such a modification, it is desired that the coupling ring 24 is made of a nonmagnetic substance and the screw 25 is made of a magnetic substance. For the sake of brevity, the permanent magnet 7 is omitted from FIG. 7. Additionally, the coupling ring 24 constitutes a substantially ring-shaped coupling member set forth in claim 5.

[0078] A magnet cover may be disposed as a protective member at least on the outer side of the permanent magnet 7 in the radial direction of the rotor 1. The magnetic cover serves to prevent fragments of the permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1 in the event the permanent magnet 7 is broken for some reason.

[0079] Several modifications, in which a magnetic cover is provided in the vehicular alternator of the present invention, will be described below one by one.

[0080] FIG. 8 is a sectional view corresponding to FIG. 3, showing the positional relationship between the claws 5Aa, 5Ba of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described first embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. In FIG. 8, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 8 shows only one pole constituted by each of the claws 5Aa, 5Ba as with FIG. 3.

[0081] Referring to FIG. 8, an outer surface of the permanent magnet 7 in the radial direction of the rotor 1 closely contacts a magnetic cover 26 having substantially the same rectangular shape as the outer surface of the permanent magnet 7. The magnetic cover 26 is preferably made of a nonmagnetic substance having superior rust resistance, such as stainless steel, so that the magnetic flux of the permanent magnet 7 disposed between the adjacent claws 5Aa, 5Ba of the claw-type magnetic poles 5A, 5B acts effectively. In this modification, the magnetic cover 26 is retained in place by the flanges 22. While the magnetic cover 26 is provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claws 5Aa, 5Ba (exactly speaking, the auxiliary magnetic pole portions 21) of the claw-type magnetic poles 5A, 5B.

[0082] FIG. 9 is a sectional view corresponding to FIG. 6, showing the positional relationship between the claws $5Aa_2$, $5Ba_2$ of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described third embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. In FIG. 9, similar components to those in FIG. 6 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 9 shows only one pole constituted by each of the claws $5Aa_2$, $5Ba_2$ as with FIG. 6.

[0083] Referring to FIG. 9, as with the modification described above with reference to FIG. 8, an outer surface of the permanent magnet 7 in the radial direction of the rotor 1 closely contacts a magnetic cover 26 having substantially the same rectangular shape as the outer surface of the permanent magnet 7. Preferably, the magnetic cover 26 is made of a nonmagnetic substance having superior rust resistance, e.g., stainless steel, so that the magnetic flux of the permanent magnet 7 disposed between the adjacent claws $5Aa_2$, $5Ba_2$ of the claw-type magnetic poles 5A, 5B acts effectively. In this modification, the magnetic cover 26 is likewise retained in place by the flanges 22. While the magnetic cover 26 is provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claw-type magnetic poles 5A, 5B (exactly speaking, the claws $5Aa_2$, $5Ba_2$).

[0084] This modification is also adaptable for the case of rotating the rotor 1 at high speeds by interconnecting the claws $5Aa_2$, $5Ba_2$ by the coupling ring 24 described above with reference to FIG. 7.

[0085] With the above two modifications, in addition to the similar advantages to those in the first embodiment, another advantage can be obtained in preventing fragments of the broken permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1 in the event the permanent magnet 7 is broken for some reason.

[0086] When magnetizing the permanent magnet 7 in the above two modifications, the magnetic cover 26 is bonded to the outer surface of the permanent magnet 7 in the radial direction of the rotor 1 beforehand. The permanent magnet 7 including the magnetic cover 26 is disposed between the adjacent claws of the claw-type magnetic poles 5A, 5B, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is

preferably magnetized in a final stage of the process for manufacturing the rotor **1**. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0087] While each of the above two modifications has a structure that the outer surface of the permanent magnet **7** in the radial direction of the rotor **1** is protected by the magnetic cover **26** in the form of a plate, the present invention is not limited to such a structure. Because surfaces of the permanent magnet **7** other than the magnetic pole surfaces thereof impose no effects upon the magnetic characteristics, the magnetic cover may have, for example, a shape surrounding surfaces of the permanent magnet **7** other than the magnetic pole surfaces thereof. In other words, the magnetic cover may have various shapes within the scope not departing from the technical concept of the magnetic cover. A description is now made of modifications of the vehicular alternator according to the present invention, in which a magnetic cover is provided to surround four surfaces of the permanent magnet **7** other than the magnetic pole surfaces thereof, with reference to **FIGS. 10 and 11**.

[0088] **FIG. 10** is a sectional view corresponding to **FIG. 5**, showing the positional relationship between the claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles **5A**, **5B** and the permanent magnet **7** provided in a modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. **FIG. 11** is a perspective view showing an overall structure of the magnet cover shown in **FIG. 10**. In **FIG. 10**, similar components to those in **FIG. 5** are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, **FIG. 10** shows only one pole constituted by each of the claws $5Aa_1$, $5Ba_1$ as with **FIG. 5**.

[0089] As shown in **FIGS. 10 and 11**, a magnetic cover **26A** has a frame-like shape surrounding the four surfaces of the permanent magnet **7** other than the magnetic pole surfaces thereof. Inner peripheral wall surfaces of the magnetic cover **26A** are finished with such a high degree of accuracy as enabling those wall surfaces to come into a very close contact with the four surfaces of the permanent magnet **7** other than the magnetic pole surfaces thereof. Preferably, the magnetic cover **26A** is also made of a nonmagnetic substance having superior rust resistance, e.g., stainless steel, so that the magnetic flux of the permanent magnet **7** disposed between the adjacent claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles **5A**, **5B** acts effectively. In this modification, the magnetic cover **26A** is likewise retained in place by the flanges **22**. While the magnetic cover **26A** is provided in this modification, both the magnetic pole surfaces of the permanent magnet **7** are entirely held in contact with the claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles **5A**, **5B** (exactly speaking, the auxiliary magnetic pole plates **23**).

[0090] With this modification, in addition to the similar advantages to those in the first embodiment, another advantage can also be obtained in preventing fragments of the broken permanent magnet **7** from ejecting outward of the rotor **1** due to the rotation of the rotor **1** in the event the permanent magnet **7** is broken for some reason.

[0091] When magnetizing the permanent magnet **7** in this modification, the permanent magnet **7** in a not yet magnetized state is first inserted in the magnetic cover **26A** such that it closely contacts the inner peripheral wall surfaces of the magnetic cover **26A**. Then, in that condition, the two auxiliary magnetic pole plates **23** are arranged to position on the magnetic pole surfaces of the permanent magnet **7**. As seen from **FIG. 10**, each of the auxiliary magnetic pole plates **23** has substantially the same dimensions as a lateral surface of the magnetic cover **26A** in the circumferential direction (left-and-right direction in **FIG. 10**) of the rotor **1**. The auxiliary magnetic pole plates **23** are fixedly joined to the magnetic cover **26A** by, e.g., welding to form a box, and the permanent magnet **7** is held in close contact with inner wall surfaces of the box.

[0092] After assembling the magnetic cover **26A**, the two auxiliary magnetic pole plates **23**, and the permanent magnet **7** into an integral unit as described above, the unit is disposed between the adjacent claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles **5A**, **5B** such that the auxiliary magnetic pole plates **23** closely contact the claws $5Aa_1$, $5Ba_1$. The permanent magnet **7** is then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet **7** is preferably magnetized in a final stage of the process for manufacturing the rotor **1**. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0093] In the above three modifications, the magnetic covers **26**, **26A** each constitute a protective member set forth in claim 9.

[0094] As a matter of course, the magnetic covers **26**, **26A** may be optionally combined with any of the first to third embodiments described above.

[0095] Moreover, by providing a magnetic holding portion, which serves to mechanically hold the permanent magnet, on a part contacting the permanent magnet, such as the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion and the auxiliary magnetic pole plate, the permanent magnet in a not yet magnetized state can be prevented from slipping off from the position between the claws of the claw-type magnetic poles, thus resulting in an improvement of the efficiency in works of, for example, assembling the rotor and magnetizing the permanent magnet.

[0096] Several modifications, in which a magnet holding portion is provided in the vehicular alternator of the present invention, will be described below one by one.

[0097] **FIG. 12** is a sectional view corresponding to **FIG. 3**, showing the positional relationship between claws $5Aa_3$, $5Ba_3$ of the claw-type magnetic poles **5A**, **5B** and the permanent magnet **7** provided in a modification of the above-described first embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In **FIG. 12**, similar components to those in **FIG. 3** are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, **FIG. 12** shows only one pole constituted by each of the claws $5Aa_3$, $5Ba_3$ as with **FIG. 3**.

[0098] In this modification, as shown in FIG. 12, a magnet holding portion 21Aa is provided at an inner end (on the lower side in FIG. 12) of each of auxiliary magnetic pole portions 21A in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between the magnet holding portion 21Aa and the flange 22. While the magnet holding portions 21Aa are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claws $5Aa_3$, $5Ba_3$ of the claw-type magnetic poles 5A, 5B (exactly speaking, the auxiliary magnetic pole portions 21A). The remaining construction is the same as that of the first embodiment. It is needless to say that the magnet holding portion 21Aa is also applicable to the third embodiment.

[0099] FIG. 13 is a sectional view corresponding to FIG. 5, showing the positional relationship between the claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In FIG. 13, similar components to those in FIG. 5 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 13 shows only one pole constituted by each of the claws $5Aa_1$, $5Ba_1$ as with FIG. 5.

[0100] In this modification, as shown in FIG. 13, a magnet holding portion 23Aa is provided at an inner end (on the lower side in FIG. 13) of each of auxiliary magnetic pole plates 23A in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between the magnet holding portion 23Aa and the flange 22. While the magnet holding portions 23Aa are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the auxiliary magnetic pole plates 23A. The remaining construction is the same as that of the second embodiment.

[0101] FIG. 14 is a sectional view corresponding to FIG. 5, showing the positional relationship between the claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in another modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In FIG. 14, similar components to those in FIG. 5 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 14 shows only one pole constituted by each of the claws $5Aa_1$, $5Ba_1$ as with FIG. 5.

[0102] In this modification, as shown in FIG. 14, magnet holding portions 23Ba, 23Bb are provided respectively at an inner end (on the lower side in FIG. 14) and outer end (on the upper side in FIG. 14) of each of auxiliary magnetic pole plates 23B in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between them. While the magnet holding portions 23Ba, 23Bb are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the auxiliary magnetic pole plates 23B. The remaining construction is the same as that of the second embodiment.

[0103] When magnetizing the permanent magnet 7 in the two modifications described above with reference to FIGS. 13 and 14, the auxiliary magnetic pole plates 23A or 23B are previously bonded to the surfaces of the permanent magnet 7 (both the left and right lateral surfaces in FIGS. 13 and 14), which are to be magnetized. The permanent magnet 7 including the auxiliary magnetic pole plates is disposed between the adjacent claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is preferably magnetized in a final stage of the process for manufacturing the rotor 1. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability. In the modification shown in FIG. 14, particularly, the work efficiency is improved because the auxiliary magnetic pole plate 23B has substantially the same shape in a vertical section as viewed in FIG. 14. Thus, that shape of the auxiliary magnetic pole plate 23B eliminates the necessity of due care for checking which side is above when assembling the permanent magnet 7 including the auxiliary magnetic pole plates 23B, which have been bonded to the magnetized surfaces of the permanent magnet 7, between the adjacent claws $5Aa_1$, $5Ba_1$ of the claw-type magnetic poles 5A, 5B.

[0104] With the above three modifications, in addition to the similar advantages to those in the first embodiment, other advantages are obtained in that the permanent magnet 7 in a not yet magnetized state can be prevented from slipping off from the position between the claws of the claw-type magnetic poles 5A, 5B toward the side of the field windings 6, and the efficiency in works of, for example, assembling the rotor 1 and magnetizing the permanent magnet 7 can be improved.

[0105] In practice, because of machining allowances, surface roughness and other reasons, it is difficult to form the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. such that such a part is surely brought into contact with the whole of the magnetic pole surface of the permanent magnet. Looking from the microscopic point of view, there is a possibility that the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. are not perfectly in contact with (but just simply cover) the whole of the magnetic pole surface of the permanent magnet. From the practical point of view, however, such a case can also be regarded as in fact falling within the condition that the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. are substantially in contact with the whole of the magnetic pole surface of the permanent magnet. Therefore, similar advantages to those in the above embodiments can also be obtained.

[0106] Further, as a matter of course, the structure of the auxiliary magnetic pole portion 21' being effective to realize reinforcement of the strength and a smoother flow of the magnetic flux, and the structure of the flange 22' being effective to reduce noise, which have been described above with reference to FIG. 4, are also applicable to any of the above embodiments and the modifications thereof.

[0107] While the above embodiments have been described in connection with, by way of example, the vehicular alternator of the type that a current is supplied to the rotating field windings **6** through the brushes **13***a*, **13***b*, the present invention can also be applied to, e.g., a brushless vehicular alternator in which field windings are kept fixed. Thus, similar advantages to those in the above embodiments can be obtained when the present invention is applied to any type of vehicular alternator wherein a permanent magnet is disposed between adjacent claws of claw-type magnetic poles.

[0108] Also, while the flanges **22**, **22'** are provided in the above embodiments as a structure for preventing the permanent magnet **7** from ejecting outward of the rotor **1** due to the rotation of the rotor **1**, the present invention is not limited to such a structure. For example, without needing the flanges **22**, **22'**, a similar advantage can be obtained by employing a structure wherein each claw is formed to have a greater width in the circumferential direction of the rotor on the outer side than on the inner side in the radial direction of the rotor, and a trapezoidal permanent magnet is formed to have a greater width in the circumferential direction of the rotor on the inner side than on the outer side in the radial direction of the rotor, the permanent magnet being disposed between adjacent claws.

[0109] As described above, according to the first aspect of the present invention, since each claw of claw-type magnetic poles is formed to have a shape coming into contact with the whole of a magnetic pole surface of a permanent magnet, almost all of the magnetic flux outgoing from the permanent magnet is rendered to flow into the claw, whereby the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet can be reduced. It is therefore possible to effectively utilize the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles, and to increase the output of the vehicular alternator.

[0110] Also, according to the second aspect of the present invention, since an auxiliary magnetic pole plate contacting the whole of the magnetic pole surface of the permanent magnet is interposed between each claw and the permanent magnet, almost all of the magnetic flux outgoing from the permanent magnet is rendered to flow into the claw-type magnetic poles through the auxiliary magnetic pole plates, whereby the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet can be reduced. It is therefore possible to effectively utilize the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles, and to increase the output of the vehicular alternator.

What is claimed is:

1. A vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, said rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on said pair of claw-type magnetic poles, and field windings coiled radially inward of said plurality of claws,

wherein each of said plurality of claws of said rotor is formed to have a shape coming into contact with the whole of a magnetic pole surface of said permanent magnet.

2. A vehicular alternator according to claim 1, wherein each of said plurality of claws has an auxiliary magnetic pole portion contacting the whole of the magnetic pole surface of said permanent magnet.

3. A vehicular alternator according to claim 2, wherein said auxiliary magnetic pole portion is formed to have a greater width on the outer side in the radial direction of said rotor than on the inner side in the radial direction of the rotor.

4. A vehicular alternator according to claim 1, wherein each of said plurality of claws is formed such that an inner surface of each claw in the radial direction of said rotor is substantially parallel to an outer surface thereof in the radial direction of said rotor.

5. A vehicular alternator according to claim 4, wherein said plurality of claws are interconnected by a substantially ring-shaped coupling member.

6. A vehicular alternator according to any one of claims 1 to 5, wherein each of said plurality of claws has a magnet holding portion for holding said permanent magnet.

7. A vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, said rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on said pair of claw-type magnetic poles, and field windings coiled radially inward of said plurality of claws,

wherein an auxiliary magnetic pole plate contacting the whole of a magnetic pole surface of said permanent magnet is interposed between each of said plurality of claws and said permanent magnet.

8. A vehicular alternator according to claim 7, wherein said auxiliary magnetic pole plate has a magnet holding portion for holding said permanent magnet.

9. A vehicular alternator according to any one of claims 1 to 8, wherein a protective member is disposed at least on the outer side of said permanent magnet in the radial direction of said rotor.

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